Nuclear Science Research Facility
- Particle and Photon Beams -

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Dr Evgeny Syresin	JINR, Dubna, Russia, February 7–8, August 20-26, 2002
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Dr Georg P.A. Berg	KVI, Groningen, Netherland, December 3, 2002

Scope of Research

Particle and photon beams generated with accelerators and their instrumentations both for fundamental research and practical applications are studied. The following subjects are being studied: Beam dynamics related to space charge force in accelerators: Beam handling during the injection and extraction processes of the accelerator ring: Radiation mechanism of photons by electrons in the magnetic field: R&D to realize a compact synchrotron dedicated for cancer therapy; and Irradiation of materials with particle and photon beams.

Research Activities (Year 2002)

Presentations

Ion beam cooling at Laser-equipped Storage and Cooler Ring, LSR, Noda A, Fadil H, Shirai T, Grieser M, Yamada S and Noda K., Annual Meeting Phys. Soc. Jpn., 24 March, 2002.

Design of Ion Cooler Ring, LSR at ICR, Kyoto University, Shirai T, Fadil H, Tongu H, Noda A et al., Annual Meeting Phys. Soc. Jpn., 24 March, 2002, The 8th European Particle Accelerator Conference, 6 June, 2002.

Electron Cooling of Ion Beams with Large Energy spread, Fadil H, Shirai T, Noda A, Grieser M et al., Annual Meeting Phys. Soc. Jpn., 24 March, 2002, The 8th European Particle Accelerator Conference, 5 June, 2002.

Ion production with a high-power short-pulse laser for application to Cancer Therapy, Noda A, Iwashita Y, Nakamura S, Shirai T, Tongu H et al., The 8th European Particle Accelerator Conference, 3 June, 2002, Ion production by focusing a high-power laser on a thin foil and its application, Nakamura S, Tongu H, Shirai T, Iwashita Y, Noda A, Daido H et al., Annual Meeting Phys. Soc. Jpn., 27 March, 2002.

Pulse stretcher of electron beam with use of the third integer resonance and RFKO method, Sugimura T, Morita A, Tongu H, Shirai T, Iwashita Y and Noda A, Annual Meeting Phys. Soc. Jpn., 27 March, 2002, Pulse stretcher operation of the electron storage ring, KSR, Noda A, Fujimoto S, Iwashita Y, Shirai T, Tongu H, Morita A and Sugimura T, The 8th European Particle Accelerator Conf., 5 June, 2002.

Laser Ion Production as the Injector for Cancer Therapy Synchrotron, Noda A, Iwashita Y, Nakamura S, Shirai T et al., The 21st International Linac Conf., 22 August, 2002

Grants

Noda A, Beam Accumulation and Cooler Ring, Advanced Compact Accelerator Research, April 2002 - March 2003.

Iwashita Y, Super Strong Permanent Magnet for Final Focus Lens in Linear Collider, Grant-in-Aid for Scientific Research, (A) (1), April 2002 - March 2003.

Iwashita Y, High gradient acceleration with standing-wave structure for linear collider, KEK joint research and development program, April 2002 - March 2003.

Ion Production with High-Power Short-Pulse Laser

For the purpose of downsizing the scale and cost of the accelerator dedicated for cancer therapy, ion beams produced by focusing a high-power (100TW) short-pulse (20fs) laser on a solid thin film has been studied as a candidate for the injection beam into a pulse synchrotron. As such ion beams have wide energy spread, reduction of the energy spread with use of phase rotation as illustrated in Fig. 1, has been studied. The ion beams are accelerated or decelerated by the phase locked RF electric field to the pulse laser according to their arrival time at the RF cavity. With this scheme, energy spread is expected to be reduced from ± 5% to ±1%.

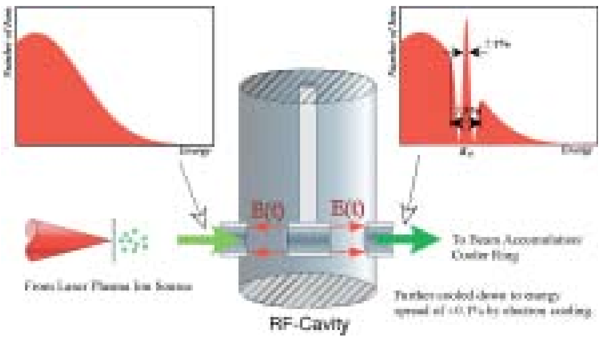

Figure 1 Scheme of phase rotation by RF electric field phase locked to the pulse laser.

Preliminary experimental results of laser ion production has been obtained using a pulse laser with several TW pulse peak power with duration of ~50 fs. In Fig. 2, the angular distributions of produced ions by the laser from thin foil targets of Ti(20μm) and CH (100μm). In this condition, the suppression of the pre-pulse is not sufficient and target-normal forward peak is not observed. Ions up to the energy of 600 keV are detected by CR39 plates.

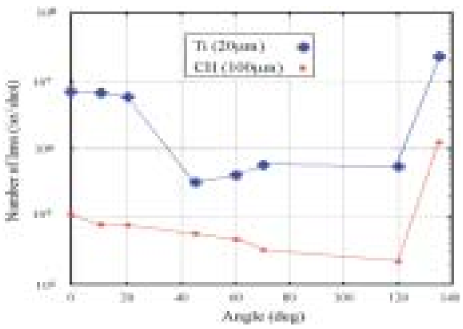

Figure 2 Angular distribution of produced ion number.

Electron Cooling of Hot Ion Beam

Electron cooling has so far been believed to be efficient only for rather cool beam [1] and is applied to cool down it to much lower temperature. Stochastic cooling has been utilized to cool down hot ion beams as anti-protons produced from solid target. Stochastic cooling, however, needs longer cooling time for higher number of particles. In order to cope with this situation, a scheme to combine electron cooling with the acceleration by an induction accelerator is proposed [2] and has been tested with use of ion storage and cooler ring, TSR at Max-Planck-Institute für Kern Physik, Heidelberg, Germany[3].

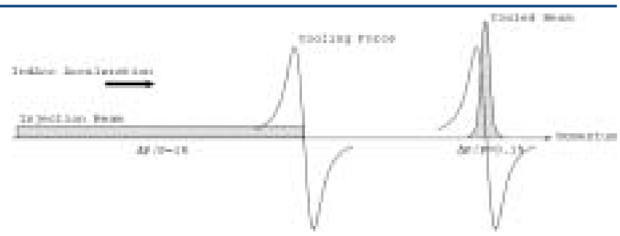

Figure 3 Scheme of electron cooling of hot ion beam with use of induction accelerator.

As shown in Fig. 3, the electron cooling force is effective only in the region of the momentum spread of 0.1% (corresponds to energy spread of ±0.1%). Our basic idea is to sweep the ion energy through this efficient cooling region by acceleration with induction accelerator. In Fig. 4, the needed time at TSR to shift the ion beam with the momentum -1% different from the central one to the center (0%) are shown for various induction voltages. It is known from the figure that the needed time to cool the beam -1 % lower than the central momentum is factor 4 reduced from 2.8 s to 0.6 s by application of 0.4 V for the induction acceleration (maximum value attainable at TSR).

As the alternative of this method, the scheme to sweep the electron energy throughout the region of the ion beam energy spread by changing the high voltage to accelerate the electron is also tested at TSR. With this scheme cooling times for 1 % momentum difference are measured to be 0.35 sec, 0.5 sec and 0.8 sec for beams with the horizontal size (FWHM) of 0.8 mm, 8 mm and 16 mm, respectively. Both methods are comparable and detailed studies are needed in connection with transverse beam size, which will be performed at LSR now under construction at NSRF, ICR, Kyoto University.

1. Möhl D, Proc. of ECOOL84, KfK 3846, 293 (1984)
2. Noda A et al., Beam Science and Technology, **6**, 21 (2001)
3. Fadil H et al., to be submitted to Nucl. Instr. and Meth.

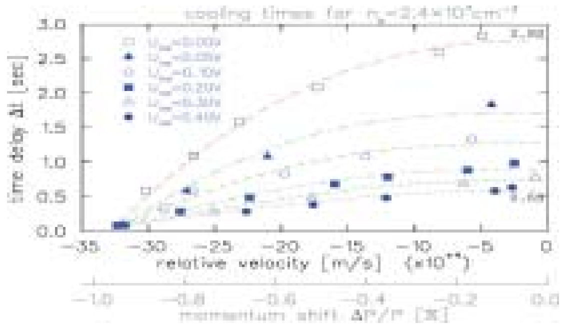

Figure 4 Cooling time for various induction voltage.